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ABSTRACT

This study sought to determine the effects of prior knowledge on the achievement of undergraduates in an economics course at the Open University of the Netherlands (OuN). A total of 49 law and 39 economics students were given 4 instruments to test prior knowledge of economics, presented with a learning unit from the course "Economics and Money," and then post-tested on subject mastery. Multiple regression analysis of the results demonstrated that prior expertise accounted for 16 to 17 percent of the variance in posttest scores. The results indicated that study time was not a relevant independent variable and did not help explain variance in posttest scores. (Contains 16 references.) (MDM)

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Analysis of the quality and impact of expertise in economics

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ABSTRACT

This report reflects the result of a research project, involving economics and law students, and focusing on the quality and impact of their expertise (or prior knowledge) in relation to the course "Economics and Money". Special attention was paid in this project towards the construction of different tests to be able to grasp the complex nature of prior knowledge at the content level. In relation to the quality of expertise, the results of this project could reveal that economics and law students possess a composite of different expertise components. In relation to the impact of prior knowledge on the acquisition of subject-oriented knowledge, regression analysis shows that expertise accounts for 16-17% of the variance in posttest scores. Although this percentage is limited, further analysis could reveal that especially optimal requisite knowledge and mathematics is important in this perspective. These results are important since they might be helpful to guide future initiatives to support students in the initial stage of their studies to cope with the demands of specific domains to be studied. In the actual study, also 'study time' was used as an independent variable to hypothesize about differences in expertise in the impact on the acquisition of new subject matter. No significant findings could be derived to support hypotheses in this context.

1. INTRODUCTION.

Earlier research and overviews of recent theories and research concerning the effect of prior knowledge (expertise) on learning, indicate that prior knowledge is one of the most important educational variables (Dochy, 1988). We define prior knowledge or expertise as the domain-specific knowledge and skills, available and necessary to tackle specific learning tasks. Domain is considered to be the total knowledge base related to an academic discipline, for example psychology, medical science or economics.

In order to investigate prior knowledge phenomena and their potential impact on the learning process, we conducted a series of experiments with the course 'Economics and Money'. This is a multi-functional course, which means that it is part of and supposed to fit for all students in different curricula within the university.

The actual research, discussed in this text, is based on earlier findings and can be considered as an attempt to validate a new approach to the evaluation of the quality and impact of expertise in a specific domain. The specificity of our approach is described in part 2 of the text when discussing the theoretical background. In our approach, special attention is paid to the construction of a set of expertise tests to measure a complex of expertise components. After summarizing the research procedure and the research results, important implications of the actual study for future investigations are presented.

2. THEORETICAL BACKGROUND.

Both from an experiential point of view (Miller Cleary, 1989) and from the researcher's point of view (Glaser, 1984) the importance of prior knowledge is stressed. Glaser (1984) states for instance that in education and thinking, "people continually try to understand and think about the new in terms of what they already know". Earlier research and our own research have tried to detect the impact and the quality of expertise. We review - in short - some basic research results in order to put the actual research in context.

Although - in literature - the impact of prior knowledge is often stressed so intense that all learning might depend on it (Resnick, 1983), also other factors like student characteristics do influence the learning process and can interact with the impact of prior knowledge. But, it is yet not clear which personal or contextual variables play a significant role in this context (Ferguson-Hessler, 1989). Moreover, research indicates that, if different variables are taken into account, "prior knowledge" always has the strongest general effect and overrules other variables in descriptive and declarative models (Ethington, 1990; Bruinsma and Gearts, 1988). This pre-dominance of expertise in learning brings Glaser (1987) to the conclusion that the assessment of factual knowledge should be stressed or studies should be conducted to assess the knowledge state of the learner. A common practice in this perspective is the explicitation of the rules that can account for systematic error patterns in task-performance. The explicitation of these rules can help to construct declarative models of understanding. Typical examples of this approach are Siegler's rule assessment approach in science concepts (1981) and Brown and Burton's "buggy" system in arithmetic computation (1978).

In our own research projects, expertise was analyzed in relation to an introductory course in economics.
The results of a first project suggested that differences in expertise are to be found between economics students and law students. These differences were derived from differences in pass rates and number of examination trials (Dochy & Bouwens, 1990).
A further investigation of 'the Heerlen Group' revealed that these differences are not significant in terms of differences on university test scores. Nevertheless, multiple classification analysis (MCA) shows very consistent trends : economics students score systematically higher than law students. It could also be shown that no personal or contextual variables are useful as indicators of a student's prior knowledge (Dochy, Bouwens, Niestadt, Wagemans, 1991). In this latter study, 76 variables (i.e age, sex, prior education, motives, work experience, etc.) which could give a direct or indirect indication of a subject's expertise, were introduced.

The research results discussed above have in common that they stress the importance of future research, focusing on the detection of specific measures of expertise which can shed light on specific component of expertise. The actual research is an attempt in this direction : we want to grasp a students' prior knowledge and its impact on learning, by concentrating the initial focus on the construction of a set of prior knowledge state tests. In past research, existing course-related tests were mostly used to assess prior knowledge (De Corte, 1991), without differentiating between types of expertise along certain dimensions (Dochy, 1990).

This research invoked different tests, varying along this content dimension. In subsequent investigations, we will search the influence of educational, epistemological and psychometrical dimensions.

In the actual investigation, prior knowledge or expertise is defined as the overall domain-specific knowledge and skills, available before the execution of a certain learning task. 'Domain-specific' refers to what is specific for a science i.e. a science discipline. In our case, this domain is 'economics' which can be sub-divided into different subject matters, e.g. accountancy, financing, etc.

In order to define the variants along the content dimension, content experts (i.e. economists) were asked to ascertain types of content knowledge that influence learning results. Moreover, we also reviewed the types of tests used in literature.
Within the tests, used to grasp an individuals' mastery of the domain, we can distinguish a tripartite, i.e. subject-oriented knowledge state tests (SO-KST), mathematics tests (MA-KST) and optimal requisite knowledge state tests (OR-KST).

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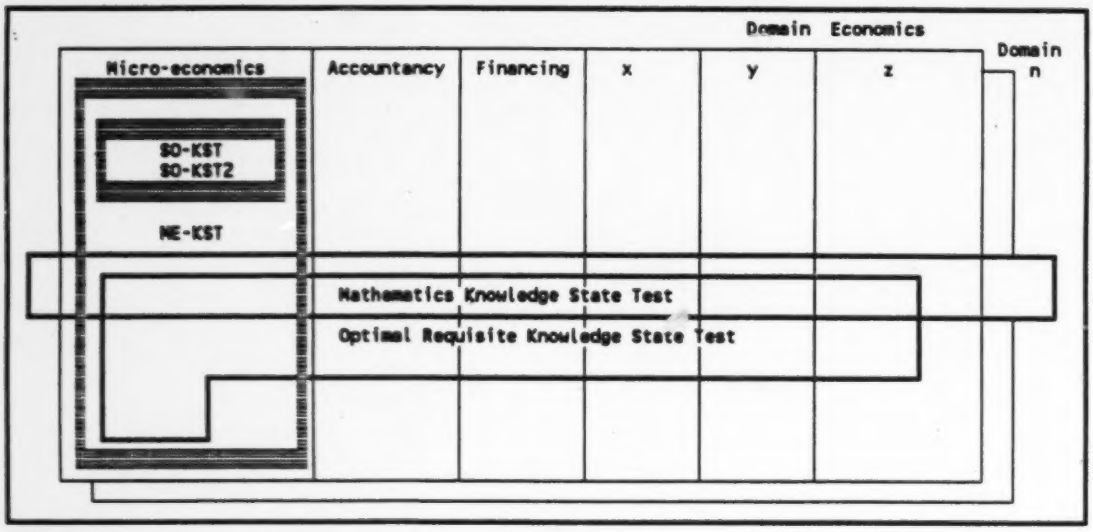
Figure 1 gives an overview of these types of different tests in relation to the domain of economics.



SO KST:	Subject-oriented knowledge state test	Subject-oriented tests
SO KST2:	Posttest	
ME KST:	Micro-economics knowledge state test	
OR KST:	Optimal requisite knowledge state test	Cross-section tests
MA KST:	Mathematics knowledge state test	

Figure 1: Different knowledge state tests in relation to the domain.

This investigation focuses on subject-oriented knowledge (SO) and a cross-section of SO knowledge, i.e. optimal requisite (OR) knowledge and mathematics (MA) knowledge. Optimal requisite knowledge is this part of prior knowledge that is, according to content experts, necessary to start the study of the learning task/course under optimal conditions.

Based on our earlier research (Dochy, 1988), we expect that higher scores on subject-oriented and cross-section expertise tests will result in higher scores on a posttest. We do not expect differences between student types (ES and LS), following the results of ex post facto research 2 (Dochy, Bouwens, Niestadt, Wagemans, 1991). Nevertheless, we replicated the analysis with the 'student type'-variable, although the current research focuses on the quality and impact of expertise. The main reasons for this are :
- this investigation differs fundamentally from the former ex post facto research in this sense that there is a treatment of the experimental group; - secondly, our focus on a broader scale of knowledge state tests could result in emerging differences as suggesed in ex post facto research 1 (Dochy & Bouwens, 1990).
Also study time was introduced as an independent variable. According to the "accessibility" theory (Spilich, Vesonder, Chiesi and Voss, 1979) and he "representation-saving" theory (Johnson and Kieras, 1983), more prior knowledge leads to shorter study time. This appears also from our research among experts[1] (Dochy, 1989). Also the explanatory model of Bruinsma and Geurts (1988) states that study time is a central factor in getting good study results. The basic idea behind all this is the connection between level of expertise and study speed, resulting in higher scores.

[1] i.e. experts in cognitive and edcational psychology.

3. RESEARCH DESIGN.

3.1 Hypotheses

Taking into account the theoretical background of the current investigation, the following two groups of hypotheses can be put forward :

1. The quality of expertise in ES and LS :
   - The overall expertise of ES and LS do not differ.
   - ES and LS do not possess a different composition of expertise components.

2. The impact of expertise and expertise levels on knowledge acquisition: - Expertise influences the posttest scores.
   - Specific expertise components influence the posttest scores.
   - Students with better expertise obtain higher scores for the posttest scores.

3. The role of study time:
   - Shorter study time reflects higher levels of expertise and results in posttest scores related through study time.

3.2 Research population

Subjects in this study are enroled as students of the Economics and Law Faculties of the University of Limburg. The choice for this research population was based on several - practical - considerations and a number of research findings. Although the actual research is set up in an Open University context and it is our intention to apply the research results for this context, it appears to be very difficult to involve a large sample of the Ou population in experiments. The latter is especially true if the research implies grouping of students studying a specific course, having to complete a specific task at a specific place on a specific date and time. In our opinion, extrapolation of research findings from students involved in regular higher education to students in a Ou-setting is possible. Research revealed for instance that personal and contextual variables are not significant indicators of students' prior knowledge (Claeys et.al., 1981; Dochy, Bouwens, Niestadt, Wagemans, 1991), thus indicating that the type of university-setting might have only a minor influence in this perspective. The selected population seems therefore to be appropriate for testing the specific set of hypotheses.
Aiming for a sample of hundred subjects, 110 students were selected at random. From this initial sample, 88 (39 ES and 49 LS[2]) subjects could be involved in the entire experimental procedure.

[2] LS refers to Law Students; ES refers to Economics Students.

3.3 Instruments

3.3.1 Description of the research instruments

In this investigation the construction of a set of five short tests was based on the following considerations:

- in order to detect the differential role of components of prior knowledge, the tests should reflect these components;
- the student load for completing the tests should be restricted;
- the research procedure should be restricted to the time limit of one day;
- within this time limit there should be enough time for students to complete the learning task.

The following tests are used :

- A SO-KST: This test includes 12 multiple-choice items (4 alternatives) and is related to learning units 14 and 15 of the "Economics and Money" course. Validity of the test was checked by content experts who evaluated if the items were representative for the subject-matter.
- An OR-KST: This test consists of 8 items (open-ended or multiple-choice), each of them representing a set of sub-items (17 in total). Construction of this test was based on the opinion of economics experts who identified and explicitated the optimal requisite knowledge for the execution of the learning task.
- A ME-KST: This subject-oriented tests covering the subject-matter of micro-economics consists of 11 items. This is a representative sample of the itembank of the Maastricht Economics Faculty. Items are of the true/false type.
- A MA-KST: This test, cross cutting the domain, contains 28 items. The test is based on a self-evaluation test of the Antwerp University.
- A posttest (SO-KST2): This test, consisting of 12 items is a parallel test-version of SO-KST.

3.3.2 Psychometric qualities of the research instruments

During test-construction of the tests, special attention was paid to content-validity. This was realized by involving content experts (SO-KST, OR-KST) or by using valid item banks (ME-KST, MA-KST).

To assess the reliability of the tests, the α-coefficient was calculated.

Table 1: Reliability of tests.

	alpha
SO-KST	.4050
OR-KST	.6899
ME-KST	.4382
MA-KST	.8233
SO-KST2	.2339

Item-test correlation for all tests reveals that there are no items with negative or low correlations to the total score. Nevertheless, reliability is to be considered as rather low, mainly due to the limited amount of items in the tests. It is generally accepted that a test needs 40 items to reach a reliability of .80. For the micro-economics KST, it is to be said that this tests is an excerpt of a domain-referenced item bank, in which items are located covering the whole domain, thus not measuring a homogeneous set of sub-aspects. For the MA-KST holds that the original Antwerp test (ref. Dijck) had a reliability of .85.

3.4 Research procedure

The research procedure consists of 10 phases :

:

- Registration and introductory session.
  During this session, the main aim of the research project and the research procedure was outlined.
- The administration of the four expertise tests :
  SO-KST (± 20 min.)
  OR-KST (± 45 min.)
  ME-KST (± 15 min.)
  MA-KST (± 45 min.)
- A first study period (± 45 min.) : during this study period the students studied the text of learning unit 14 & 15 of the course "Economics & Money". The study task was limited to the individual going through the course text. There was no control of individual approaches towards the study task. Text-support was equal to the regular support provided in Ou-courses.
- Lunch time (30 min.)
- During a second study period (± 45 min.), the students could continue with their study of the course text.
- Administration of the posttest (± 15 min.).
- Concluding session.

The administration of a set of expertise tests was a specific feature of this research as explained in the introductory parts of this text.
The overall procedure was timed according to a strict time schedule, but avoiding time stress or fatigue. In this way, the net study time i.e. the time effectively utilized for studying was registered.

4. DISCUSSION OF THE RESEARCH RESULTS.

4.1 General results

Table 2 gives an overview of the mean scores and the standard deviation of the student-scores for the four different prior knowledge tests and the posttest :

Table 2 : mean scores for the prior knowledge tests and the posttest

	m	std. dev.
SO KST	5.0	2.05
OR KST	8.5	3.84
ME KST	3.6	1.89
MA KST	12.8	5.43
POSTT.	6.6	1.77
PKST1	30.0	9.87
PKST2	21.4	6.92

To calculate a general measure of expertise, the scores for the four prior knowledge tests have been added to each other (PKST1). Correlation analysis between the four expertise tests reveals that the optimal requisite test and the mathematics-test do correlate to a high extent ($.635^{***}$)[3]. This is to be expected, since the optimal requisite test contains items, based on the mathematics domain. Since both tests measure - to a certain extent - the same type of expertise, a second general measure of prior knowledge has been calculated, excluding the scores for the optimal requisite test (PKST2).
The mean and standard deviation of both general measures of expertise can also be found in table 2.

4.2 The quality of expertise in economics.

4.2.1 The overall expertise of Economics Students (ES) and Law Students (LS) is not different.

Analysis of variance of the overall expertise scores (PKST1 & PKST2) of ES and LS reveals significant differences in expertise level of the two groups[4]. Table 3 shows the mean scores of the two groups of students, the maximum score and the analysis of variance statistics :

Table 3 : Differences in expertise between LS and ES

	m					MCA	
	ES	LS	max	F	pF	ES	LS
PKST1	35.94	22.38	59	76.38	.000	6.01	-7.55
PKST2	25.37	16.33	51	63.61	.000	4.00	-5.03

The second part of the table shows the results of the multiple classification analysis. The mean deviance of the mean of ES is always positive and always negative for LS. These significant differences in expertise between ES and LS are in contradiction with our earlier findings (Dochy et.al., 1991; ex post facto research 2). In our opinion this may be due to the effort - in the actual project - paid towards the construction of a variety of instruments to measure expertise. In this way, the instruments are more sensible to measure differences in expertise. As a consequence it is interesting to check whether the actual composition of expertise components is different in law and economics students.

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[3] *** $p < .001$

[4] The variances of ES and LS are equal for both general measures of expertise (t-test).

4.2.2 ES and LS do not possess a different composition of expertise components.

As expected from the former analysis, there are specific differences in the composition of expertise components in LS and ES[5] :

Table 4 : Differences in expertise components between LS and ES

	m					MCA	
	ES	LS	max	F	pF	ES	LS
SO KST	5.73	4.05	12	17.44	.000	.75	-.945
OR KST	10.57	6.05	8	45.54	.000	2.00	-2.52
ME KST	3.98	3.10	11	4.84	.030	.39	-.49
MA KST	15.65	9.18	28	47.18	.000	2.87	-3.60

The results in table 4 are very consistent. With the exception of the test scores for ME KST ($.001 > p < .05$), there is a significant difference between ES and LS in relation to the specific expertise components. Moreover, each time the same trend is to be found (cfr. mean scores and MCA) : the expertise level of ES is higher than the expertise level of LS. These differences are extremely high for the optimal requisite test and the mathematics expertise test. As indicated earlier, the optimal requisite test correlates to a high extent with the mathematics expertise test since the former contains items applying mathematics. This implies that the SO KST and the MA KST seem to be of main importance when describing differences in expertise between ES and LS.
This finding could be of interest when looking at the potential impact of expertise on learning. Has, e.g. mathematics expertise an important impact on learning subject-oriented knowledge in relation to economics ?

4.3 The impact of expertise on knowledge acquisition.

4.3.1 Expertise influences the posttest scores.

In order to be able to measure the impact of expertise on learning new economics knowledge, a subject-oriented posttest[6] was administered to all students after an experimental treatment. During this treatment, all students received a specific study task.

To detect the impact of expertise on the knowledge acquisition regression analysis has been used to define the extent to which the prior knowledge scores help to explain the variance in the results for the posttest.

Table 5 : Regression analysis of general expertise scores

	R2	% explained
PKST1	.17	17%
PKST2	.16	16%

The results in table 5 indicate that expertise - as measured by the four (PKST1) or three (PKST2) expertise tests - helps to explain 16 a 17% of the variance of the posttest results.
Although this impact is significant, one can comment that this figure is still restricted. Other variables - related with expertise or other independent variables - seem to influence the posttest scores. Nevertheless, taking into account the conclusion of part 4.2 of this text, it might be interesting to look at the complex of expertise components to determine form a further quantitative analysis what type of expertise the 16 - 17% of explained variance stands for.

[5] The variances of ES and LS are equal for the 4 different measures of components of expertise (t-test).

[6] This posttest was a parallel version of the SO KST. Both tests reflect the subject-content dealt with during the study task.

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4.3.2 Specific expertise components influencing the posttest scores.

If we enter all the testscores in the regression equation, we get the following picture; indicating the % each separate expertise test helps to explain the variance in the posttest scores :

Table 6 : Regression analysis of expertise component scores

	R2	% explained
SO KST	.07	6%
OR KST	.11	11%
ME KST	.01	1%
MA KST	.13	13%

Already at this level we can see that the mathematics expertise test (MA KST) and the optimal requisite test (OR KST) explain a large proportion of the variance in the posttest scores. But a further analysis is needed to determine exactly what the specific contribution of each expertise is. In order to do this, a stepwise regression analysis has been calculated[7]. Only the mathematics expertise test and the subject-oriented expertise test (SO KST) are withheld and entered in the regression equation. Both tests explain 13% of the variance in the posttest results. The scores for the optimal requisite test and the other subject-oriented expertise test do not seem to add any relevant (Pout = .1) and significant explanatory power.
These results do confirm the pre-dominant impact of optimal requisite and mathematics expertise in learning of economics, and a lesser impact of subject-oriented knowledge.

4.3.3 Students with better expertise obtain higher posttest scores.

To check this hypothesis, the results of two sub-groups of students have been used. The scores of 25% of the students with the highest scores (H) and the scores of 25% of the students with the lowest scores (L) for expertise in general (PKST1 & PKST2) and for each of the specific expertise tests have been used in the analysis[8]. We checked whether students with high or low scores for the specific expertise tests, do also obtain significantly different results for the posttest[9].

Table 7 : The impact of low and high scores for expertise tests on the posttest scores

	M				MCA	
	L	H	F	pF	L	H
PKST1	5.09	7.21	18.90	.000	-1.01	1.01
PKST2	5.18	7.19	17.4.	.000	-1.09	.92
SO KST	5.81	6.73	4.411	.041	-.54	.38
OR KST	5.28	6.65	7.960	.007	-.79	.58
ME KST	5.88	6.30	.680	.413	-.21	.20
MA KST	5.73	7.17	9.953	.003	-.74	.71

Having a low or high expertise score (PKST1 & PKST2) is significantly reflected in differences in posttest scores. When looking at the specific expertise tests, we can also conclude that with the exception of ME KST, we can confirm the hypothesis that differences in expertise test scores are mirrored by posttest scores[10]. Students with high expertise test scores obtain high posttest scores[11].

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[7] Taking into account the high intercorrelation between the optimal requisite test and the mathematics test, it is expected that not all expertise scores will be entered in the regression equation.

[8] The letter L and H in the table refer to the group with Low results and the group with High scores for each specific expertise test.

[9] The mean scores of the high and low group for the specific expertise tests are significantly different ($p < .0005$).

[10] In relation to the first expertise test (subject-oriented) the hypothesis is confirmed at the 5% level ($p < .05$).

4.4. Shorter study time reflects higher levels of expertise and results in higher posttest scores.

In order to detect the potential role of study time on learning new economics knowledge, the time spent by students to finish the study task was registered. This study time varied from 62 minutes to 130 minutes. To make a further analysis of the study time-related hypothesis, students were divided into three groups, based on their study time[12].

Analysis of variance revealed that the differences in study time are not reflected in significant differences in expertise scores (general measure of expertise (PKST en PKST2) and expertise components). Multiple regression analysis shows that study time makes no contribution to explain the variance in posttest scores.

[11] This analysis has been replicated in another sense : 25% of the students with the highest and lowest scores for the posttest have been compared in relation to their expertise test scores. The results of this analysis (t-test) are consistent with the results in table x : PKST1 ($t=-3.65$, $p_t=.001$); PKST2 ($t=-3.73$, $p_t=.000$); SO KST ($t=-2.70$, $p_t=.009$); OR KST ($t=-2.5$, $p_t=.01$); ME KST ($t=-.89$, $p_t=.378$); MA KST ($t=-3.34$, $p_t=.001$).

[12] 1 = < 77'; 2 = > 76' and < 87'; 3 = > 86'.

5. CONCLUSIONS.

The results of this study concerning the quality and impact of expertise in economics has revealed some relevant results with implications for the content and organisation of education in the field of economics.

The first conclusion is that the variable "student type" (ES or LS) has been helpful to detect differences in expertise within a population of students. Moreover, these differences could be extrapolated in terms of specific components of expertise. Striking were the differences in mathematics expertise and optimal requisite knowledge between both sub-populations. This fact strongly contradicts the multi-functional nature of the course "Economics and Money" and implies structural, organisational of educational adaptations of this course towards these differences.

The second important conclusion of this research is that it could be stated that the level of expertise predicts - to a certain degree - future learning results of students. Although the predictive power of the expertise tests used is still limited (16-17%), further analysis revealed that most of the predictive power was related with optimal requisite knowledge and certainly mathematics.

Thirdly, the results show that study time is not a relevant independent variable, reflecting differences in expertise and having an impact on learning new subject matter. This variable does not help to explain variance in the posttest scores and differences in study time are not reflected in significant differences in posttest scores.

The results are helpful to indicate directions for further research. It looks for instance promising to analyze in more detail the complex of components in expertise. In this research project, expertise components were defined along a "content dimension". In the near future, other dimensions can be put forward to analyze expertise.

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